

THE CRETACEOUS-TERTIARY BOUNDARY BIOTIC CRISIS IN THE BASQUE COUNTRY  
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The Zumaya section has been selected as a classic locality for the study of the Cretaceous-Tertiary (K/T) boundary due to its richness in microfauna (1), macrofauna (2, 3), and nannoflora (4). The Sopelana section (5) the Biarritz section (6, 7), the Monte Urko section, etc. present similar good conditions for the study of the K/T boundary. The sedimentary rocks of the Uppermost Maastrichtian from the Basque Country are purple or pink marls and marlstones. Above it is found a clayed bed, 40 cm-29 cm. thick, grey or dark grey in its basal part, of Lowermost Danian age. Above there is alternation of micritic grey-pink limestones and thin clay beds of Dano-Montian age. The average sedimentation is 7-8 times higher during the Upper Maastrichtian than in the Dano-Montian.

The macrofauna underwent a decrease since the Campanian (2) and was not found in the last 11 m of the Zumaya section (2, 3); it was associated with changes in paleoceanographic conditions and primary productivity of the oceans (8). Recently (9), it has been found a relatively diversified fauna of ammonites in the previous "barren zone" at the top of the Maastrichtian in other sections near Zumaya. On the other hand, the microfossils are always present throughout the sections and allow to recognise all the planktonic foraminifera and nannoflora zones around the K/T boundary. The Uppermost Cretaceous is characterised by the Mayaroensis Zone -planktonic foraminifera- and the Prinsii Zone -nannoflora-, both present in our sections. The Lowermost Paleocene is characterised by the Eugubina Zone; in its very lowest boundary (K/T boundary) there is a "flood" of Thoracosphaera spp. (4, 5, 7, 10).

The microfossil assemblages in the K/T transition allow us to recognize several phases of a complex crisis between two well established planktonic ecosystems, one of the Mayaroensis Zone before the extinction of Abathomphalus mayaroensis (Bolli) and the other of the Tenuis Zone, then after the appearance of Cruciplacolithus tenuis (Stradner).

In the Mayaroensis Zone there is a stable ecosystem with 45-47 planktonic foraminifera species, some of which just appeared at the lower part of this zone. The nannoflora shows minor changes with the appearance of Micula prinsii Perch-Nielsen.

The disappearance of A. mayaroensis starts a degradation of the ecosystem. The number of planktonic foraminifera species decreases between 20% and 45%; their percentage with regard to the total of foraminifera decreases between 8% and 20% or their percentage in weight decreases in 2 or 3 times, just below the K/T boundary. The main species are heterohedidids rather than Globotruncana spp. The degradation is strongly increased in the last 10 cm below the K/T boundary with the appearance of opportunistic nannoflora species (persistent species) although their percentages are less than 5%. Based on the average sedimentation rates this phase may last about 30000-40000 years, with a clear strong degradation in its last 1000 years, before the K/T boundary.

The next phase of the crisis was the result of main extinction events in the planktonic calcareous ecosystem. There are several cretaceous planktonic foraminifera species, probably reworked, whose numbers decrease upward. The Paleocene planktonic foraminifera are very rare and smaller than 0.1 mm, in these first 10 cm of the Boundary Shale. The calcareous nannoflora underwent a first decrease of its Cretaceous species and an increase of opportunistic species up to 50%; a second decrease of Cretaceous species reduces its

percentage to 15%. There are several geochemical anomalies in these materials and an Iridium spike (11, 10). The destruction of the Upper Cretaceous planktonic ecosystem shows an apparent delay between the planktonic foraminifera and nannoflora extinctions; which might be related to alkalinity changes of the shallow ocean waters (12). The microfossil assemblage is typical from a pioneer ecosystem. If the clay sedimentation rate was the same than during the Upper Maastrichtian age, the length of this phase could be computed in 25000 years.

The next and last phase of the biotic crisis shows a diversification of the ecosystem; the number of planktonic foraminifera is 2-3 times higher than before and it is noted the first appearance of Tertiary nannoflora species, while Cretaceous species ("survivor" species) decrease and persisting species are still the main ones. The appearance of Cruciplacolithus tenuis (Stradner) starts the occurrence of a stable and diversified ecosystem, although not as rich as the Upper Maastrichtian one. The crisis may last 0.5 My, which is the span between the last occurrence of A. mayaroensis (Bolli) and the first occurrence of C. tenuis (Stradner) in this region.

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